SALT MINING DREDGE

ELECTRIC 1100 HP LADDER PUMP WITH 94” DUAL WHEEL EXCAVATOR

Salt Mining Dredge Contract Challenges

- Production Guarantee established minimum solids requirement
- Bucket Wheel required to dig un-blasted halite
- 85% minimum material recovery required
- Up-cutting wheel design puts heavy loads on forward gantry and hull
- Customer pre-selected slurry pump
- Dredge required to operated reliably in temperatures up to 130F (54C)
- Control system required to manage existing booster train
- Coating and corrosion plan required to allow operation in a brine pond
- Required to build to Petrochemical Industry standards
- Modular design required for inland transportability
- Assembly and Testing required at Ellicott
- Disassembly for Ocean Freight
- Reassembly and Launch at remote and difficult salt ponds


WARNING


THE SOUTHERN GALVANIZING COMPANY
DANGER
FALL PROTECTION REQUIRED BEYOND THIS POINT
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Salt Mining Dredge as Delivered

Halite

Halite Properties

- Chemical Composition = NaCl
- Crystal Structure = Cubic
- Specific Gravity ~ 2.1
- Moh’s Hardness ~ 2.5
- Reported UCS of deposit ~ 10-16 MPa

Salt Mining Dredge Characteristics

- Molded Dimensions ~ 124’ L x 48’ W x 7’ D (38m x 15m x 2m)
- BV Classed Floatation
- Overall Length ~ 165’ (50m)
- Draft ~ 4.5’ (1.5m)
- Digging Depth ~ 33’ (10m)
- Electrically Powered from shore (4.16 kV)
- Air cooled
- PLC Control of Dredge and 4 boosters

Pumping System Details

- Ladder Installation
- Warman 14x12 TKG Gravel Pump
- 1100 hp (820 kW) 8 pole motor
- Variable Speed Drive with limited maximum speed and managed acceleration ramp
- Composite Drive Shaft
- Expansion Joints
- 18” (0.45m) on-board suction and discharge pipe

Pumping System Challenges

- Production Guarantee established minimum solids requirement
- Brine carrier fluid is very heavy (1.2 to 1.3 SG)
- Typical particle sizes 1” to 3” (25mm to 75mm)
- Flow limited by dewatering wheel capacity
- High solids content and very high slurry densities
- Little data available about line losses and/or line speeds
- Cavitation concerns during shallow digging
- Suction clogging concerns

Excavator Details

- 8’ (2.4m) diameter wheel
- Double wheel with integral hopper to feed suction mouth
- 630 hp (475 kW) Hydraulic Drive
- 30 rpm maximum adjustable speed drive
- Gear drive

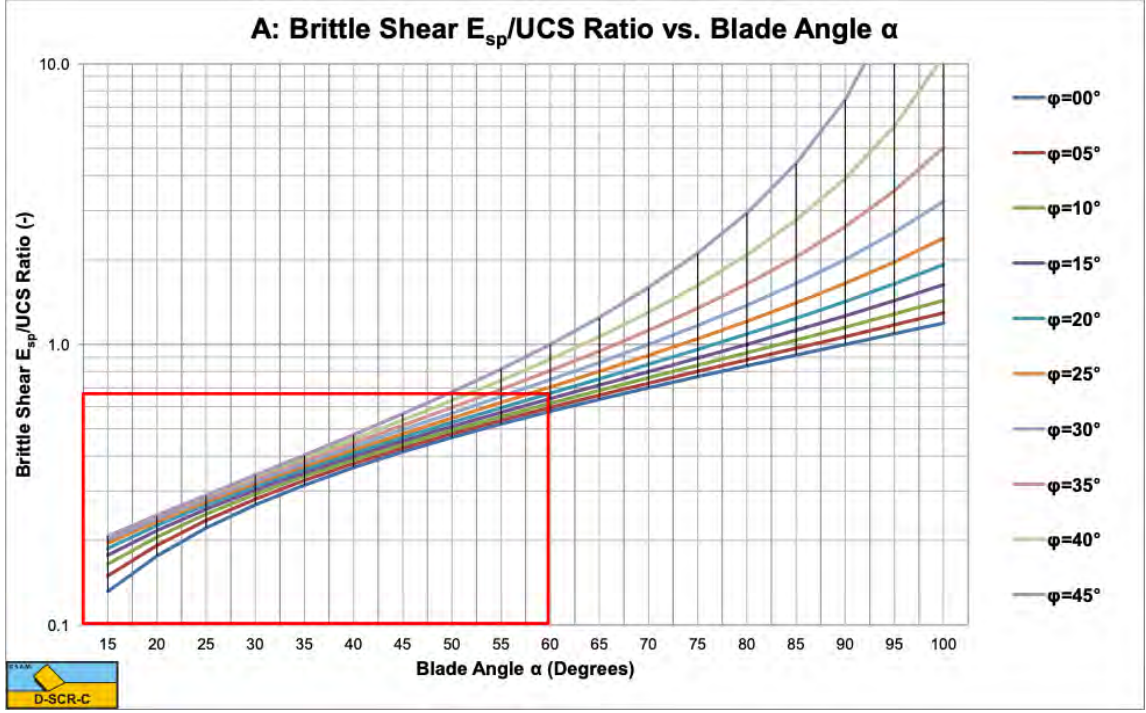
Excavation System Challenges

- Production Guarantee established minimum solids requirement
- Difficulty in advancing double sided wheel in hard material
- Volumetric Capacity limited by wheel size and swing speed
- Capacity limited by cutting force and shaft power
- Little data available about power requirements to cut halite

Excavation Consultation

- Ellicott consulted with Dr. Sape Miedema
- Needed to understand relationship between material strength and power requirements
- UCS 10-16 MPa, BTS 1-2 MPa (based on ratio UCS/BTS of 8)
- Internal friction by default 20 degrees, external friction 2/3 of internal friction
- Installed power 475 kW (0.475 MW)
- The cutting process is either the Flow Type (shear failure) or the Tear Type (tensile failure), the one giving the smallest Esp should be chosen

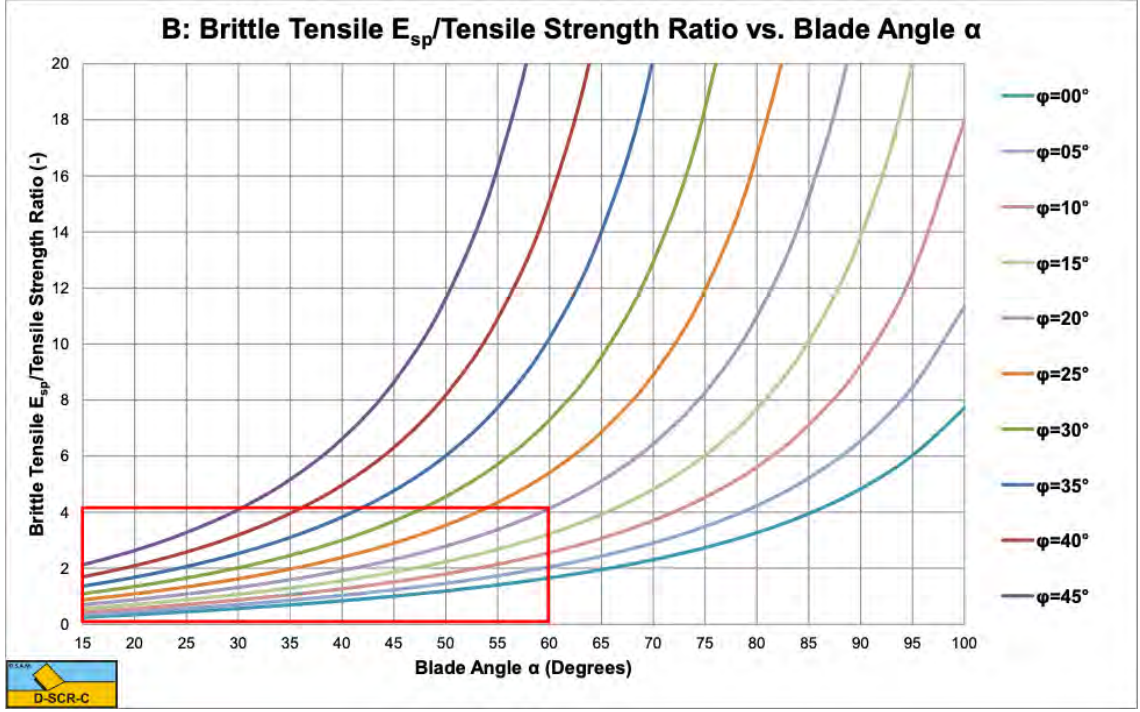
Flow Type



- Esp/UCS=0.7
- giving Esp=7 MPa for 10 MPa halite
- Giving Esp=11 MPa for 16 MPa halite
- Production=0.475/7=0.068 m^3/s for 10 MPa halite
- Production=0.475/11=0.043 m^3/s for 16 MPa halite

- Choosing a 50 degree blade angle and 5 degree internal friction angle gives 0.1 m^3/s (360 m^3/hr) and 0.063 m^3/s (230 m^3/hr)

Tear Type



- An Esp/sigmaT is found of 4.
- Giving Esp=5 MPa for 10 MPa halite
- Giving Esp=8 MPa for 16 MPa halite
- Production=0.095 m^3/s (342 m^3/hr) for 10 MPa halite
- Production=0.06 m^3/s (214 m^3/hr) for 16 MPa halite

- So Tear Type gives smaller Esp and larger production, we have to choose Tear Type

Conclusions

- The factory testing, commissioning, and performance testing were successfully completed to the customer’s satisfaction.
- The pumping system performed better than expected.
- For the excavation cases considered the Tear Type gives the smallest specific energies and the highest productions. So, the expectation is tensile failure with big pieces of halite entering the suction mouth. For more accurate estimations, the internal friction angle and the tensile strength of the halite should be determined.
- The productions estimated match the productions realized.